

Claims

What is claimed is:

1. A method of making an oriented calcium fluoride single crystal, comprising:
loading calcium fluoride feedstock on top of a seed crystal having a specific crystallographic orientation;
heating the calcium fluoride feedstock to a temperature sufficient to form a melt; and
growing a calcium fluoride crystal on the seed crystal by progressively moving the melt and the seed crystal through a temperature gradient zone having an axial temperature gradient in a range from approximately 2°C/cm to approximately 8°C/cm;
wherein a growth direction of the calcium fluoride crystal substantially conforms to the crystallographic orientation of the seed crystal.
2. The method of claim 1, wherein the seed crystal has [110] crystallographic orientation.
3. The method of claim 1, wherein the seed crystal has [100] crystallographic orientation.
4. The method of claim 1, wherein the axial temperature gradient is in a range from approximately 2°C/cm to approximately 6°C/cm.
5. The method of claim 1, wherein the axial temperature gradient is in a range from approximately 3°C/cm to approximately 5°C/cm.
6. The method of claim 1, wherein the seed crystal is partially melted to ensure that the growth direction of the calcium fluoride crystal substantially conforms to the crystallographic orientation of the seed crystal.
7. The method of claim 1, wherein a solid-liquid interface between the calcium fluoride crystal and the melt is constrained to be within the temperature gradient zone.

8. The method of claim 1, wherein the calcium fluoride crystal has a mean birefringence no greater than approximately 1.2 nm/cm and inhomogeneity no greater than approximately 1.1 ppm.
9. The method of claim 1, wherein the temperature gradient zone is created between a first zone and a second zone in a vertical furnace, the first zone having a higher temperature than the second zone.
10. The method of claim 9, wherein the calcium fluoride feedstock is heated in the first zone.
11. The method of claim 10, further comprising annealing the calcium fluoride crystal in the second zone.
12. The method of claim 11, wherein annealing the calcium fluoride crystal in the second zone comprises cooling the calcium fluoride crystal to a first temperature.
13. The method of claim 12, wherein the first temperature is in a range from approximately 1300°C to approximately 1100°C.
14. The method of claim 11, wherein annealing the calcium fluoride crystal further comprises cooling the calcium fluoride crystal to a final temperature at a substantially constant cooling rate.
15. The method of claim 14, wherein the final temperature is in a range from approximately 300°C to approximately 20°C.
16. The method of claim 14, wherein the final temperature is in a range from approximately 100°C to approximately room temperature.
17. The method of claim 14, wherein the cooling rate is less than or equal to approximately 3°C/hr.
18. The method of claim 14, wherein the cooling rate is less than or equal to approximately 2°C/hr.

19. The method of claim 12, wherein cooling the calcium fluoride to a first temperature comprises applying a decreasingly fast cooling profile to the first zone and an increasingly slow cooling profile to the second zone to diminish a temperature difference between the first zone and the second zone.
20. The method of claim 1, wherein a translation speed of the melt through the temperature gradient zone is less than 3 mm/hr.
21. The method of claim 20, wherein the translation speed of the melt through the temperature gradient zone is in a range from approximately 0.5 mm/hr to less than approximately 3 mm/hr.
22. The method of claim 1, wherein a translation speed of the melt as it moves through the temperature gradient zone does not vary by more than approximately 0.1 mm/hr.
23. A calcium fluoride crystal for making optical elements for transmitting below 200-nm ultraviolet light having a [100] crystallographic orientation and a diameter greater than or equal to approximately 250 mm and exhibiting a mean birefringence no greater than approximately 1.2 nm/cm and inhomogeneity no greater than approximately 1.1 ppm.